



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification<sup>5</sup> :</b> <b>C22C 1/09, F16D 69/02</b> <b>C23C 4/06</b>	<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 92/05292</b> <b>(43) International Publication Date:</b> 2 April 1992 (02.04.92)
<b>(21) International Application Number:</b> PCT/GB91/01577 <b>(22) International Filing Date:</b> 13 September 1991 (13.09.91)  <b>(30) Priority data:</b> 9020182.3 14 September 1990 (14.09.90) GB 9115663.8 19 July 1991 (19.07.91) GB  <b>(71)(72) Applicant and Inventor:</b> MURPHY, Martin, John, Michael [GB/GB]; Lane End Cottage, Hoggston near Winslow, Buckinghamshire MK18 3LL (GB).  <b>(74) Agent:</b> SHAW, Laurence; George House, George Road, Edgbaston, Birmingham B15 1PG (GB).		<b>(81) Designated States:</b> AT, AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CA, CF (OAPI patent), CG (OAPI patent), CH, CH (European patent), CI (OAPI patent), CM (OAPI patent), CS, DE, DE (European patent), DK, DK (European patent), ES, ES (European patent), FI, FR (European patent), GA (OAPI patent), GB, GB (European patent), GN (OAPI patent), GR (European patent), HU, IT (European patent), JP, KP, KR, LK, LU, LU (European patent), MC, MG, ML (OAPI patent), MN, MR (OAPI patent), MW, NL, NL (European patent), NO, PL, RO, SD, SE, SE (European patent), SN (OAPI patent), SU <sup>+</sup> , TD (OAPI patent), TG (OAPI patent), US.  <b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
<b>(54) Title:</b> METAL MATRIX COMPOSITE COMPONENT  <b>(57) Abstract</b>  A metal matrix composite component e.g. a brake disc, is provided with a protective coating to prevent displacement of the reinforcing filler in the matrix when the component is placed under load. Preferably the protective coating is metal, alloy, composite, refractory or ceramic applied e.g. by electro-plating.		

# + DESIGNATIONS OF "SU"

Any designation of "SU" has effect in the Russian Federation. It is not yet known whether any such designation has effect in other States of the former Soviet Union.

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### METAL MATRIX COMPOSITE COMPONENT

The invention relates to a component formed of a metal matrix composite i.e. a continuous metal phase reinforced with a disperse phase which may or may not be metal. The matrix may be formed of a metal such as aluminium, magnesium, titanium or an alloy based on any of these; the disperse phase may be in particulate, fibre or whisker form and selected from a wide range of materials such as silicon carbide, boron carbide, alumina, carbon, sand and other refractory fillers; wires of steel, copper or silver; and the like. A typical metal matrix composite comprises from about 10% to 40% by volume of silicon carbide in a continuous phase of an alloy of aluminium/magnesium/silicon or aluminium/copper or aluminium/lithium. Composites are of value because of lightness in weight coupled with strength and stiffness properties which are exerted even at high temperatures. Such composites can be made by a wide variety of techniques.

It has been observed that under certain conditions a component made of such a composite can fail to perform its intended function properly. In a specific case, a brake disc made of such a material will fail because of the frictional engagement with known brake pads. The reasons for this are not clear but there is evidence to suggest that dispersed particles of the second material in the composite are displaced from their position in

the matrix. There would be value in using a reliable brake disc made of a metal matrix composite because of the lightness in weight, strength, stiffness, wear resistance and like properties.

Disc brakes comprising a caliper and a disc have been widely adopted, particularly for automotive applications. The disc is squeezed during braking between pads of friction material, mounted in the caliper; and since the disc has a high resistance to compression, and since much of the disc is exposed and so can cool more quickly than for instance the drum of a drum brake, a disc brake is less prone than the drum brake to brake "fade" i.e. to partial loss of braking at high disc and/or pad temperatures, as may occur following intensive brake usage over a short period. It will also be of advantage to form other components of this material able to withstand similar conditions of use. Such components can be parts used in automotive, aerospace, aeronautic, machine tool, construction and like equipment.

It is one object of this invention to provide a component formed of a metal matrix composite, which component is able to withstand stresses induced in use. e.g. applied frictional forces.

According to the invention in one aspect there is provided a component formed of a metal matrix composite, the component having a protective coating on at least one surface thereof.

Preferably the protective coating is selected to prevent displacement of the reinforcing filler or other disperse phase in the matrix when the component is placed under load. As indicated, one particular component is a brake disc which in use can be damaged by a brake pad and in this case the protective coating is selected to protect the surface against an applied abrasive force. In addition or alternatively the coating may be selected to provide corrosion resistance, hardness, wear resistance, compatability or other properties. Depending on the intended use, the coating may be selected to have thermal properties, e.g. conductivity.

Most preferably, the protective coating is applied by electroplating, plasma deposition, magnetron sputtering or a like technique.

The protective coating may be selected from a wide variety of materials. The coating is usually a metal e.g. Fe, Al, Zn, Cu, Co, Cr, W, In or alloy or a composite. One example is preferably cast iron and another is a composite based on high carbon iron, molybdenum and aluminium. The coating may be non-metallic, e.g. refractory or ceramic, e.g. alumina. Re-inforcing fibres e.g. silicon carbide, carbon may be present. The material selected will be chosen to be compatible with the component, e.g. for a brake disc it will have a rate of linear heat expansion substantially the same as that of the composite to avoid the risk

of debonding at service temperature. The coating will usually be thin say about 0.2 millimetres.

The metal matrix composite may be selected from any of the available such materials. The density may range from about 2.5 to about 3.1 gm/cm<sup>3</sup>, dependant on the materials selected.

In another aspect the invention provides a method of making a component as defined, comprising applying a protective coating to at least one surface of a component formed of a metal matrix composite.

A brake disc of the invention can be used with a wide range of available brake pads without undergoing damage in use. As a result, commercially available brake pads can be used without modification. The discs may be used at the front and/or rear of a vehicle, including a racing vehicle.

The invention will be further described by way of example with reference to the accompanying diagrammatic drawing in which:

Figure 1 is a cross-sectional view of a typical disc for use in a disc brake; and

Figure 2 is an enlarged section of a circled disc portion of Figure 1.

The vehicle brake disc 10 is of generally "top-hat" form, with a mounting bell portion 11 adapted to be secured to rotate with a vehicle wheel; in an alternative embodiment the disc can be mounted to rotate with the vehicle propshaft and may be ventilated. The bell and disc are held together in known manner, e.g. by bolts and nuts, not shown.

Friction pads A,B are movable into engagement with opposed side faces 10a, 10b of disc 10, to effect braking of the disc. During such engagement if the disc is rotating, high temperatures are generated at the disc surfaces, which may have therefore a frictionally induced surface temperature exceeding 400°C.

The disc 10 comprises a body portion 12, formed of a metal matrix composite with a coating 20 of cast iron applied by a plasma spray technique. METCO 449 is one commercially available sprayable material. As shown in Figure 2, disc 10 is of an aluminium alloy body 14 with particulate silicon carbide 16 therein, randomly but evenly distributed. The density of the matrix is about 2.76 gm/cm<sup>3</sup>. The plasma sprayed coating 20 is applied to a depth sufficient to protect the underlying metal matrix composite, typically about 0.2 millimetre, and so as to prevent any particles 16 standing proud of the surface from contacting the pad A,B in use and causing damage thereto.

CLAIMS

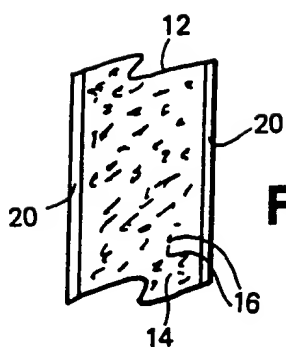
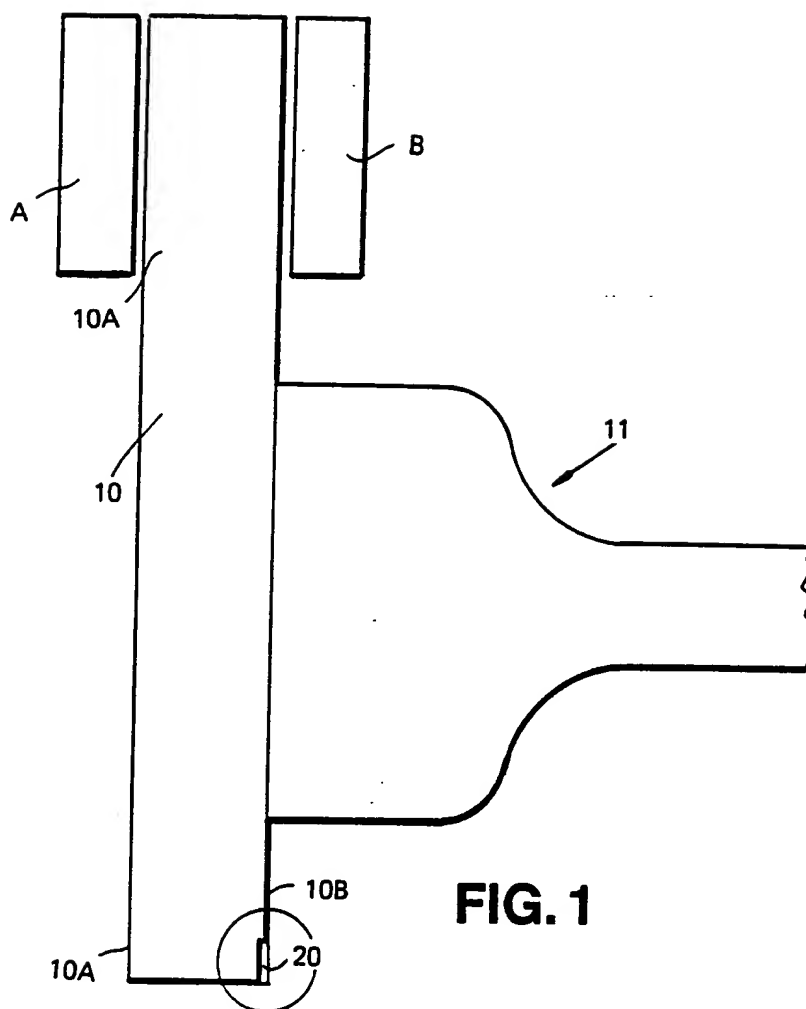
1. A component formed of a metal matrix composite, the component having a protective coating on at least one surface thereof.
2. A component according to Claim 1, in which the protective coating is selected to prevent displacement of the reinforcing filler in the matrix when the component is placed under load.
3. A component according to Claim 2, in which the protective coating is selected to protect the surface against an applied abrasive force.
4. A component according to any preceding Claim, in which the protective coating is applied by electro-plating, plasma deposition or the like.
5. A component according to any preceding Claim, in which the protective coating is a metal or alloy or composite or refractory or ceramic.
6. A component according to Claim 5, in which the protective



coating comprises particles of the materials listed herein.

7. A component according to any preceding Claim, wherein the coating is applied to a thickness of about 0.2 millimetres.
8. A component according to any preceding Claim, comprising a brake disc having a protective coating formed on opposite faces thereof.
9. A method of making a component according to any preceding Claim, comprising applying a protective coating to at least one surface of the component.
10. A method according to Claim 9, wherein the coating is applied by electro-plating, plasma deposition, sputtering, or the like.
11. A method according to Claim 9 or 10, wherein the coating is applied to a depth of about 0.2 millimetres.
12. A brake assembly comprising a set of brake pads and a brake disc according to any of Claims 1 to 8.

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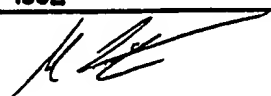


SUBSTITUTE SHEET

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 91/01577

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (if several classification symbols apply, indicate all) <sup>6</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int.Cl. 5 C22C1/09; F16D69/02; C23C4/06		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>7</sup>		
Classification System	Classification Symbols	
Int.Cl. 5	C22C ; F16D ; C23C	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>8</sup>		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup></b>		
Category <sup>10</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
X	US,A,3 755 059 (CALFEE) 28 August 1973 see claims 1-5 ---	1
X	FR,A,2 375 442 (UNITED TECHNOLOGIES CORPORATION) 21 July 1978 see claims 1,2,5 ---	1
X	PATENT ABSTRACTS OF JAPAN vol. 10, no. 176 (M-491)(2232) 20 June 1986 & JP,A,61 024 877 ( TOYOTA MOTOR CORP. ) 3 February 1986 see abstract ---	1,4,5
Y	GB,A,2 003 935 (SWISS ALUMINIUM LTD.) 21 March 1979 see claims 1-4 --- -/-	1,5
<p><sup>10</sup> Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"A" document member of the same patent family</p>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search		Date of Mailing of this International Search Report
22 JANUARY 1992		03 FEB 1992
International Searching Authority EUROPEAN PATENT OFFICE		Signature of Authorized Officer LIPPENS M.H. 

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
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A	US,A,3 902 864 (NIX ET AL.) 2 September 1975 see claims 1,3,4 ---	1,2
A	GB,A,2 164 711 (AUTOIPARI KUTATO ES FEJLESZTO VALLALAT) 26 March 1986 see claims 1-12 ---	1,2
A	FR,A,2 117 731 (AGENCE NATIONALE DE VALORISATION DE LA RECHERCHE) 28 July 1972 see claims 1-4,15-21 ---	1,4,8-10
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**ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO. GB 9101577  
SA 51309**

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		JP-A- 58157955	20-09-83
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